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The Action of the Short Rotators on the Normal Abduction of the Arm:

With a Consideration of their Action in Some Cases of Subacromial Bursitis and Allied Conditions.

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THE ACTION OF THE SHORT ROTATORS ON THE NORMAL ABDUCTION OF THE ARM, WITH A CONSIDERATION OF THEIR ACTION IN SOME CASES OF SUBACROMIAL BURSITIS AND ALLIED CONDITIONS.

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Codman, of Boston, in a recent monograph on lesions of the shoulder-joint due, in his opinion, to trauma or to primary inflammation of the subacromial bursa, has done more to clear up the interesting subject of painful shoulders, and to explain certain definite restrictions of motion between the humerus and the scapula than has been accomplished by any other investigator, and his masterly interpretation of the mechanics of the shoulder-joint is so simple, clear, and conclusive (as far as he goes) as to establish almost beyond question his contention as to the primary action of the supraspinatus in abduction of the humerus preliminary to the action of the deltoid, which is thus permitted to come into action and exert its force in the proper direction to complete the arc of abduction. He has followed his theory through the operating room and into the dissecting room, and has conclusively established his contention by anatomical specimens showing the pathological changes following rupture of the supraspinatus, with the subsequent loss of the power of abduction in these cases. He has applied his researches into the normal mechanics of the scapulohumeral joint to the practical treatment of a class of shoulder lesions showing restriction of motion and tenderness below the acromion, which, as he says, constitute by far the largest class of patients applying to any surgical clinic for the relief of trouble referable to the shoulder-joint. For this class of cases he has adopted Kuster's term of subacromial bursitis in place of the subdeltoid bursitis used by him in his first paper, although the latter term would seem to be by far the better, since more of the bursa is subdeltoid than subacromial, and since Piersol, in his recent anatomy, used the term subdeltoid in his description of the bursa. Whatever term is used, the credit must go to Codman for the most convincing description of the mechanics of this complicated joint. And in the light of his investigation the real

action of the joint does not appear to be so complicated after all. A study of normal shoulder action is necessary for the proper understanding of his cases, and the few which have come under observation which we hope to demonstrate are departures from the regular types which he has described. If one considers anatomically the origin and insertion of the various muscles surrounding the shoulder-joint, and if one bears in mind the fact that the real capsule of the joint is formed by these surrounding muscles, and not by what is known as the capsule, with its ligamentous bands, which is a lax structure neither aiding nor opposing the normal motions of the joint, it would seem to be easy to assume, and equally easy to prove from a study of the anatomical structure, that the first few degrees of motion in abduction are due to the supraspinatus contraction, and is preliminary or preparatory, as it were, to the action of the deltoid.

Piersol says that the capsule of the shoulder-joint, among other uses, by means of its tense, firm under surface helps to prevent the arm from being raised beyond a certain point in abduction, but it is extremely doubtful if the capsule has any such action, although this one is by far the more probable of all the uses ascribed to it by the various anatomists, and it is probable that the capsule per se has very little retarding action on the movements of the joint itself. As Codman says, it is necessary to disregard our previous teaching and conception of the structure which has been called the capsule. The real capsule of the joint is made up of the muscles which surround it. Codman's contentions, which are, I think, accepted for the most part or will be so accepted by all who carefully examine the anatomical structure of the shoulder-joint, bearing in mind the laxity of the capsule, are, briefly, that the first few degrees of motion in abduction of the humerus are always due to the contraction of the supraspinatus acting on the short arm of the lever, the fulcrum of which is on the glenoid, the long arm of the lever extending downward through the arm (Fig. 1).

It will be readily seen that the fulcrum of such a lever must be a constantly changing point, and that the action of such a lever would be comparatively slight, and such seems to be the case. From its insertion high up on the greater tuberosity of the humerus the action of the supraspinatus must be limited in power, because the power in that case would be applied so near the fulcrum, while the weight would be far removed (see Fig. 1: *A*, power, *C*, weight, of the lever *A*, *B*, *C*), and it is only sufficient to move the arm outward in abduction sufficiently to permit the line of pull of the deltoid (the mean line of the pull of all the fibers of the deltoid, assuming that these muscle fibers work together, which would be the line *II-E*, in Fig. 2) to fall superiorly to the fulcrum (*B*, Fig. 2) of the lever, in which case the deltoid could expend its force in abducting the arm still more. instead of uselessly forcing the humerus upward, as it would do acting in the line (*II*, *E*., Fig. 2) of its pull when inside (toward the body side) of

the fulcrum on the glenoid, thus forcing the head of the bone against the lower surface of the acromion. It will be seen, therefore, from the origin and insertion of the deltoid (from the spine of the scapula, the acromion, and the outer third of the clavicle into the deltoid tubercle midway on the external surface of the shaft of the humerus) that its action alone, provided its fibers contracted as a single muscle, would not be expended in the right direction to abduct the humerus,

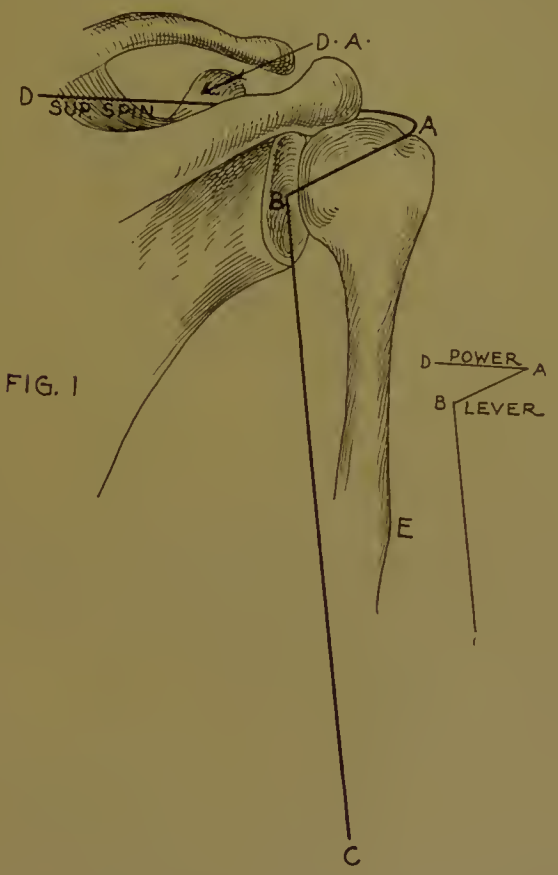

FIG. 1

FIG. 1.—*D A*, the line of pull of the supraspinatus; *A*, the power applied to the short arm of the lever; *A, B, C*, the lever; *B*, the fulcrum on the glenoid; *C*, the weight to be lifted. The contraction of the supraspinatus can swing the arm, obviously, in but one direction—abduction.

but rather would act uselessly in forcing the head of the bone against the under surface of the acromion, or if it worked too soon after primary action by the supraspinatus would force the greater tuberosity to take its fulcrum from the under surface of the acromion process (Fig. 2). If two lines of pull are at right angles to each other, and equal force is applied in both directions, the body acted upon would always feel the force thus expended in a line midway between the two equally acting forces, and if one considers the origin

and insertion of the deltoid it will be clearly demonstrated that if this muscle were acting alone it would not raise the arm in abduction (Fig. 2).

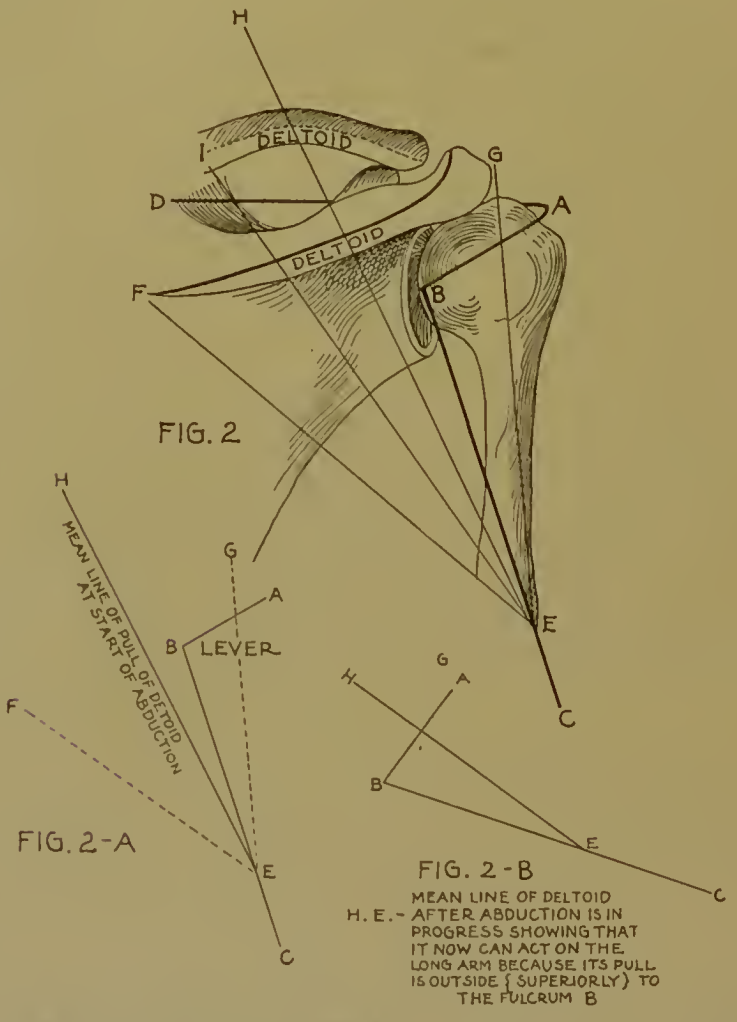

Fig. 2.—Showing the lines of pull of the fibers of the deltoid, providing these fibers acted together, *H, E*, being approximately the line of such pull, showing that in this case it could not act on the lever *A, B, C*, to abduct it. Assuming that the acromion portion of the deltoid acted as a separate muscle or as a separate contraction, then it could (consider the line *G, E*, and its effect acting at *E* on the long arm of the lever *A, B, C*) aid in starting the humerus upward in abduction, but should its fibers act simultaneously the line of pull would be inside the fulcrum, *B* (Fig. 2, *A*), and provided it was in contraction it would act in opposition to the line of pull of the supraspinatus, *D, A*. In order to act on the long arm of the lever the line *H, E*, must fall outside the point *B* (fulcrum), and this is possible only after the long arm of the lever (the humerus) has been partially abducted (Fig. 2, *B*).

The normal mechanism of the shoulder-joint is, therefore, up to this point probably as follows: The supraspinatus contracting starts the motion of the humerus in abduction, but the supraspinatus

from its insertion high up on the upper facet of the greater tuberosity of the humerus, is acting at a considerable disadvantage. It is the power applied to the short arm of a lever whose fulcrum is on the glenoid (Fig. 1, *B*, fulcrum, *D*, *A*, power). In other words, the lever is arranged, power, fulcrum, weight, the short arm of the lever being joined to the long arm at the fulcrum, at an angle which is constantly changing, and constantly becoming a more acute one as the arm rises in abduction, but which is at the beginning of motion usually a little over 45 degrees, and such a lever cannot, as said before, be one of great power. It is, however, sufficient to start the humerus outward, and begin the arc necessary to abduction, probably even up to 30 degrees, and during this time, unless the acromial portion of the deltoid acts as a separate and individual muscle from the rest of the deltoid, it can assist the action of the supraspinatus in no way (Fig. 2).

When the lever (humerus) has swung beyond a certain point the great deltoid contracting takes up the work, but it cannot do this until the supraspinatus has abducted the long arm of the lever (the humerus) sufficiently so that the deltoid contracting (the mean line of its pull when the muscles contract falling superiorly to the point of fulcrum on the glenoid) can act on the long arm of the lever, thus converting it into a more powerful one, where the power is applied as fulcrum, power, weight, and which is still aided by the power of the supraspinatus still acting on the short arm of the same lever. Should the deltoid contract before this point is reached, then the supraspinatus tendon is caught between the head of the bone and the acromion process, and either torn across or injured. As the arm reaches a certain degree of abduction the power of the supraspinatus, from its anatomical consideration, would seem to be slight, its work having been accomplished, but it would seem that its anatomical position is such as to render it of value as a tractor, possibly assisted by the lower tense part of the capsule (Piersol) to prevent slipping downward of the fulcrum (the articular surface of the head on the glenoid), thus preventing destroying the efficiency of the lever. If one looks at Fig. 3, he will see that this is the only part of the joint which is not surrounded by powerful tractors (the inferior portion), and motion here is prevented by the supraspinatus, tense superiorly, and possibly by the under surface of the capsule. If this should be so, it would be the only value as far as aiding or retarding motion in the joint rendered by the so-called capsule. Another feature to be considered is the subacromial bursa which comes into play, as Codman clearly demonstrates, when the arm is abducted, and the tuberosity of the humerus is approaching the under surface of the acromion by the interposition of its well-lubricated surface between these two bony points (preventing the tuberosity from taking its fulcrum on the under surface of the acromion, and thus restricting further motion in abduction), permitting (the force of the deltoid continuing) the

artieular surfaee of the humerus to turn in bnt one direetion, namely, towards the glenoid.

Codman's eontention is that the subacromial bursa aeeomplishes this purpose, and he goes no further. If we eonsider now the origin and insertion of these two muscles together, both aeting and the humerus partly raised in abduetion, we come to the eonsideration of the third part of the meehanics of the shoulder-joint in abduetion, a very important part, indeed, and one whieh has not been eonsidered

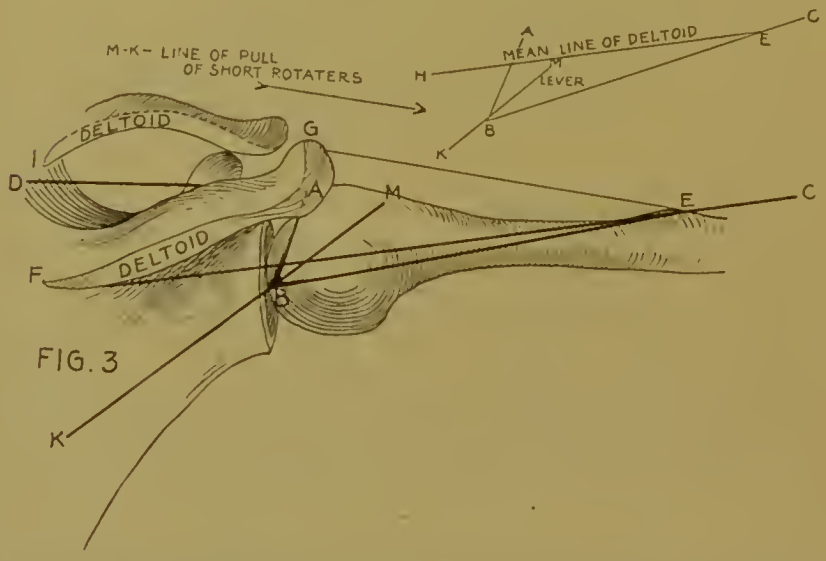

Fig. 3.—This shows the lines of pull of the deltoid when the arm is partly abducted, *G, E*, *F, E*, and *I, E*, and the line of the pull of the supraspinatus, *D, A*, aeting on the short arm of the lever *A, B, C*, while the deltoid acts on the long arm of the same lever, its power being applied to *E*, a point between the weight *C* and the fulcrum *B*. Note also that both lines of pull, deltoid and supraspinatus, are above the fulcrum *B*, and unless there is another force applied, the fulcrum of the lever would be unstable and render worthless any amount of power applied. That force, *K, M* (the line of pull of the infraspinatus and teres minor behind and of the subscapularis in front) is supplied by these three short rotators, without which the head of the humerus would slip upward, answering the pull of the supraspinatus and deltoid. Note that the line of pull of the short rotators passes through the fulcrum, therefore it acts merely as a tractor and exerts no force either on the long or short arm of the lever, consequently offering no impediment to the abduction, while at the same time rendering such action possible by keeping the fulcrum firmly in its place.

(so far as I know), bnt which I believe absolutely essential to the normal action of the joint, and whieh action is especially to be remembered in the class of cases elassified by Codman, and also in those eases the eonsideration of whieh I shall take up, and which are closely allied to the eondition known now as subacromial bursitis. As the arm eontinues to abduet, the line of pull of the supraspinatus and the line of the deltoid pull are coming nearer and nearer into line (Fig. 3, *D, A*, and *F, E*), and they are both upward and inward, and both forees are superior now to the point of the fulerum (Fig.

3, *B*). Unless there were another force to offset this upward and inward pull of these two muscles, the tendency would still be to force the tuberosity against the under surface of the acromion process, and it is inconceivable that nature should leave such a task to the slippery surface of any interposed bursa. While, undoubtedly, this interposition of the bursa is necessary, and acts to direct the articular surface of the humerus against the glenoid, and also permits the tuberosity to pass smoothly under the acromion, still, without the presence of another force acting at an entirely different angle than either the supraspinatus or the deltoid, the articular surface, while it might and probably would be directed to the proper fulcrum, would not be held firmly enough to permit of that efficiency which is present in the normal joint, and it would permit riding up of the tuberosity against the acromion with unnecessary force.

Consider the lines of pull of these two muscles inward and upward, and we can see that the tendency would still be to pull the tuberosity upward either with or without the bursa (Fig. 3). Another force applied here is an absolute necessity. Such a force is supplied when we consider the origin and insertion of the short rotators.

Following the anatomical law that the strength of opposing muscles, or the strength of the sum of opposing muscles, is equal or nearly equal, then the subscapularis and the infraspinatus, plus the teres minor, must be equal, the one an inward rotator, the others outward rotators.

But consider the insertion of these muscles so near the head of the bone, and it becomes more probable that the simultaneous contraction of these three muscles, following the primary pull of the supraspinatus and simultaneous with the contraction of the deltoid, is necessary to pull the head of the humerus into the glenoid, and fix it firmly there forming the fulcrum, and that without this additional pull the action of the deltoid would still be to force the tuberosity to take its fulcrum from the under surface of the acromian, and that this action is equally important with their well-recognized action as rotators of the arm. These three short rotators or tractors, as they should be called, form a practical sling around the anatomical neck of the humerus, and their lines of pull, when acting together, would not only enable the articular surface to find its proper fulcrum, but would also counteract the tendency of the combined action of the supraspinatus and the deltoid to pull upward the tuberosity (Fig. 3). Consider these muscles in their relation to the arms of the lever, and we see (Fig. 3) that the line of pull of these short rotators passes practically through the fulcrum of the lever, and, therefore, while exerting power sufficient to keep the articular surface constantly and firmly against the glenoid, and the tuberosity away from the acromion, thus permitting abduction of the humerus, the line of pull, passing as it does practically through the fulcrum, it could not in any way act on either arm of the lever to hinder elevation or depression

of the humerus. For a demonstration of this contraction of the subscapularis, infraspinatus, and teres minor, it is only necessary to stand behind a model who is abducting his arm, and note with the hand the tenseness of these muscles, especially after the humerus has swung past the horizontal line, in contrast with the flabby relaxed belly and tendon of the pectoralis major in the same position. Beyond a certain point, however, the infraspinatus and teres minor behind and the subscapularis in front, which have acted together up to this point solely as tractors to hold in place the articular surface of the humerus, may possibly take on an added action, although it is probably to a very limited extent, inasmuch as abduction of the humerus is by this time a nearly completed act, namely, that of abductors also, as aids of the deltoid.

The action of the supraspinatus is practically little by this time, and the short arm of the lever has ceased to be of much advantage. Its force is probably expended more as a tractor to help hold firmly the articular surface of the humerus from slipping on its fulcrum, and it is in this possibly aided by the tense, firm inferior surface of the capsule, as suggested by Piersol. A new lever, therefore, takes the place of the old (Fig. 4). Considering the articular surface of the humerus as the segment of a circle, turning constantly as the arm abducts and forming a constantly changing fulcrum or point on the glenoid, the moment that the lines of pull of the short rotators have swung upward through the fulcrum of the old lever they cease to act simply as tractors, and a new lever, or a new short arm, is formed instantly. Or, whenever the line of pull of these short rotators transects the segment of the circle above the fulcrum they become the power on the short arm of a new lever, the long arm of which remains the same (Fig. 4, *M*, *B*, *C*), and their action would be to raise the arm to a still higher level, assisting the deltoid.

The reverse of this is also true to a limited extent. Thus, the short rotators act in abduction of the humerus when the arm has passed a certain level, and act to pull it downward, adduct, after it has fallen below another fixed level on its downward course, depending on the relation of the line of pull to the fulcrum of the lever at *B*.

To recapitulate, it would seem that from a theoretical and practical consideration of the shoulder-joint, always taking into consideration the origin and insertion of its various muscles, and considering them as the power applied to the lever (the humerus), whose fulcrum in the normal shoulder would be a constantly changing point, it would seem that the necessary movements would be as follows: (1) Supraspinatus contraction would abduct the arm and tend to tip the articular surface of the humerus, so as to bring it against the glenoid, but its action and its strength are slight (30 degrees). The powerful deltoid, contracting, forces the tuberosity against the under surface of the acromion, where interposes the well-lubricated subacromial

bursa, which, the force of the pull continuing, permits the articular surface to turn in but one direction, namely, toward the glenoid.

To complete this action and in order to form a theoretically perfect mechanical entity, we must invoke another force or pull, fixing the head of the bone in the glenoid, yet having no restriction on the abduction of the arm. Such a force we have seen that we have in the combined and simultaneous action of the subscapularis on the one side, and the infraspinatus and teres minor on the other. In other words, a narrow, firm sling pressing the head of the bone into

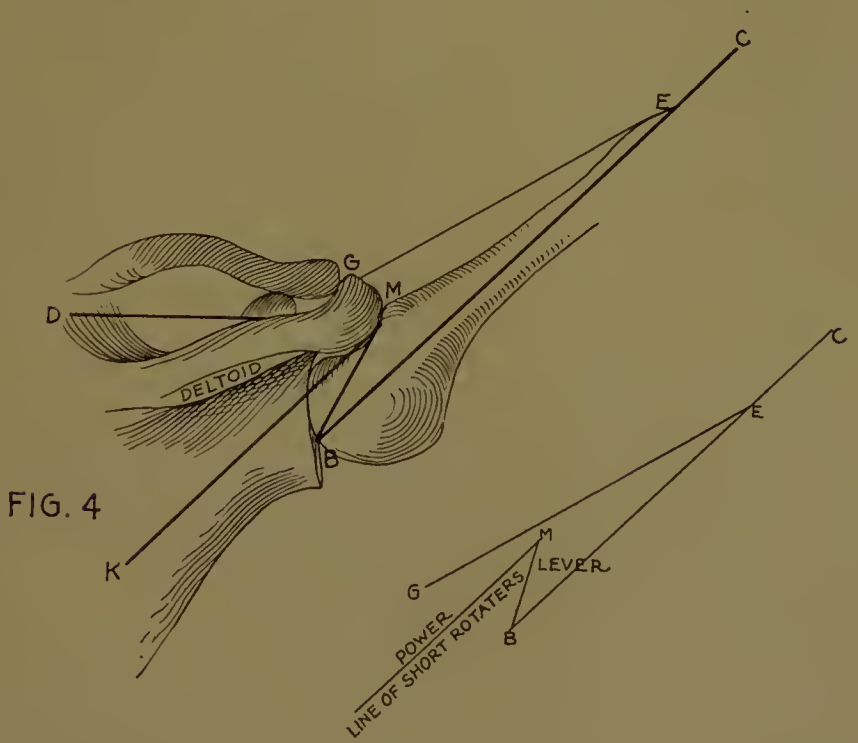

FIG. 4

FIG. 4.—*G, E*, the power applied by the deltoid at *E* to the lever *M, B, C; M*, the point where the power is applied to the short arm of the new lever by the short rotators; *B*, the fulcrum on the glenoid; *K, M*, the line of pull of the short rotators. Note that the line of pull of the short rotators (subscapular, infraspinatus, and teres minor) is in this position of the arm superior to the point of fulcrum *B*, therefore it may act slightly as an additional abductor.

the glenoid, yet not preventing abduction, but even acting above a certain point as an aid, and varying in forward and backward swinging exactly as the muscles of one side over or under acted in consideration with the opposing muscles, always, however, exerting sufficient pull to keep the articular surface firmly against its fulcrum on the glenoid cavity of the scapula.

To come now to a consideration of the subject of shoulder lesions involving the bursa, or of lesions presenting symptoms which closely

ally them to lesions of the subacromial bursa. Codman has investigated this subject thoroughly, and has written a monograph on the subject of subacromial bursitis which will become a classic. He has divided his cases into three classifications:

Type I, the acute or spasmodic form with localized tenderness just below the acromion process of the scapula, over the bursa, and to the outside of the bicipital groove. This tender point disappears under the acromion on abduction because no adhesions are present in the bursa to prevent, and this sign is considered pathognomonic of this type of bursal lesions by him (Dawbarn's sign). In abducting or in external rotation, after a certain point is reached the scapula is locked by spasm, and moves with the humerus. In mild cases, with but little spasm, the patient thinks he cannot abduct his arm, but will allow passive motion, and is usually perfectly able to abduct once he has overcome his fear of pain. Codman thinks this is explained by the unwillingness of the supraspinatus to start the pull on its sensitive tendon.

In *Type II* (the subacute or adherent type) actual adhesions exist in the bursa, and there is an actual mechanical limitation to abduction and external rotation. Localized tenderness may or may not be present, according to the degree of existing inflammation. Dawbarn's sign is absent—the tuberosity cannot pass under the acromion because of adhesions. Abduction and external rotation of the humerus on the scapula are limited; 10 degrees of free motion in abduction exist because the bursa is not brought into play before this point is reached. Beyond this arc of 10 degrees the scapula accompanies the humerus in all its motions, active or passive. Pain is in the same distribution as Type I, and in severe cases it may resemble a brachial neuritis.

Type III. The chronic type; the essential characteristics are painful motion, but the full arc exists. The trouble is due in this class to slight irregularities of contour of the base of the bursa usually external to the bicipital groove. Motion, instead of being smooth, is jerky and interrupted in its arc. Localized tenderness may or may not be present. If present, then Dawbarn's sign is present. Abduction and external rotation are but slightly interferred with, but at some point in abduction acute tenderness is experienced, which disappears as soon as the tuberosity is under the acromion. The scapula does not accompany the humerus. There may or may not be pain, and if present it is often felt at the insertion of the deltoid.

While forced to agree with all which Codman says in his paper, as far as he goes, and also that nearly all of the shoulder cases will fall into one or the other of his classification, it has been my fortune recently to come in contact with two cases, out of a total of seven, which it seems to me impossible to class with any one of the three types which he has given, and it has seemed that there was possibly

a class of cases, limited in number perhaps, and usually or always the result of trauma, the symptoms of which are practically those of subacromial bursitis, and which may be, and perhaps always are, accompanied by some inflammatory changes of the bursa, but which show distinctive symptoms sufficient to call attention to the involvement of the short rotators, the action of which Codman does not take up in his article.

These two cases, one following a dislocation unreduced for twelve hours, and the other a fall with the arm in extension, presented the same symptoms: No tender point over the bursa beneath the acromion; the greater tuberosity disappeared under the acromion; a normal active arc without pain up to 23 to 25 degrees, and then restriction, but not on account of pain; passive motion, practically throughout the entire arc; external rotation lost, internal rotation preserved; no paralysis of the deltoid.

From an examination of these cases, I am forced to the conclusion that the greater number will readily fall into Codman's classification, and that they will also show a subacromial bursitis with or without adhesions; that at autopsy evidence of tearing or fraying of the tendon of the supraspinatus will be more often observed than evidence of injury to the short rotators, but it is my contention that there is a limited number of cases which, with or without a well-defined bursitis, present certain varieties of symptoms which are not due entirely to inflammation or adhesion of the bursa, but which are due to either a tearing or more frequently an inflammatory involvement of these short rotators, more particularly the infraspinatus and the teres minor. There is no tender point over the bursa. In the acute cases of Codman there is a tender point. The greater tuberosity disappears under the acromion without pain. In his cases of acute type the tuberosity disappears under the acromion, but with pain, and in the adherent type it does not disappear at all. His cases show 10 degrees of abduction before pain. The cases under observation show 23 to 25 degrees of active abduction, and then motion was not stopped on account of pain; it was inability to lift the arm, the deltoid visibly acting. Inward rotation was preserved, and this would apply equally well to bursitis alone, the preservation being due to less involvement of the subscapularis, because it comes to a less degree into contact with the bursa. External rotation was lost, and Codman, contradicting Kuster, says that it is also true of subacromial bursitis, probably accounted for by the proximity of the posterior short rotators to the floor of the tender bursa.

In the two cases cited there is, however, no tender bursa, at least not on pressure, passive motion is practically preserved, which would not be the case in adherent bursitis, and would be painful in acute bursitis, while in his chronic type external rotation is preserved. The full arc of passive motion, the absence of tender points over the bursa, the preservation of internal rotation, the loss of external

rotation, 23 to 25 degress of painless, active abduction, and no deltoid paralysis, together with tenderness over the bellies of the infraspinatus and teres minor, and especially marked and referred outward to their insertion on using faradization, would seem sufficient to warrant us in recognizing a lesion of the shoulder-joint usually following trauma, which may be accompanied by a low grade of bursal inflammation, and may always be so accompanied, but whose chief pathological change is either a complete or incomplete rupture, or, more frequently, the involvement in an inflammatory lesion of the tendons of the infraspinatus and teres minor, and less frequently of the subscapularis.

There is also a class of fractures involving the greater tuberosity of the humerus, not so rare as has been assumed, which invariably lead to a set of symptoms resembling bursitis. Some of these cases undoubtedly develop a bursitis, and to that condition their symptoms should direct attention, but some of them present symptoms identical with those described in the two cases reported above, and it has seemed to me that involvement of the short rotators, which can be proved by the *x*-rays, is more of a factor in these particular cases than an inflammation of the bursa. In the two cases which have presented themselves to me, in which the accompanying *x*-ray prints show the nature of the lesion, there has been some question both among the clinicians and the *x*-ray men as to the exact anatomical injury, but it will be plain to anyone, without entering into a discussion of that point, that the greater tuberosity has been, at least, torn off.

In Fig. 5 it shows as an absolute loss of substance, and for the purposes of this paper it is sufficient to deal with it simply as a lesion of the tuberosity. The loss of motion to have been expected here was absolute inability to abduct and loss of external rotation with the preservation of internal rotation. This was exactly what this patient showed. He could move his arm in the frontal plane because his biceps was not involved, but he could not start his arm from the side in abduction because his supraspinatus was torn loose, and external rotation was lost because the same thing had happened to the infraspinatus and teres minor. The deltoid was not involved, and could be seen to contract vigorously both voluntarily and by faradization, but the arm was not abducted, and could not be held when passively abducted. Internal rotation was preserved because the position of the subscapularis was not involved in the injury and its belly and insertion were both intact. In this class of cases when passive motion is free and full, and the only restriction is in active motion, should there exist the 10 degrees of normal supraspinatus abduction mentioned by Codman, then it is quite clear that that tendon has not been torn away, and if the motion is painless, it is equally certain that it has escaped injury.

If the humerus is abducted painlessly to 23 or 25 degrees and the deltoid contracts and still active abduction is impossible beyond that

point, with the full arc on passive motion, and the disappearance of the tuberosity under the acromion, then the cause of the impairment of motion is, I am convinced, to be looked for in a lesion of the

FIG. 5.—Fracture of the great tuberosity of the humerus, involving the insertions of the supraspinatus, infraspinatus, and teres minor, with displacement of the fragment. There was entire loss of abduction; external rotation was lost permanently, but the power to abduct was recovered; internal rotation was preserved; forward and backward motions were possible with slight pain. (*X*-ray by A. W. George, M.D.)

short rotators. If a painful point exists (Dawbarn's sign) it is possible that a bursitis is the cause of the loss of motion, but I am convinced that there is a certain number of cases with the symptoms

mentioned in which the lesion is one involving the short rotators, more frequently the infraspinatus and teres minor, and that this is the principal lesion, whether or not associated with a bursitis. Among the cases which Codman cites is one in which passive motion was free and the tuberosity disappeared under the acromion, but with tenderness.

FIG. 6.—Fracture of the great tuberosity of the humerus, involving the tendons of insertion of the supraspinatus, infraspinatus, and teres minor; radiogram two and one-half months after the injury. Six months later external rotation was still lost. Internal rotation was preserved at all times. Some restriction in abduction still persists when the arm swings beyond the horizontal position. There is no pain; note callus. (*X*-ray by A. W. George, M.D.)

The deltoid, to quote his own words, was as big as a ham, and yet when abducted passively he could hold his arm only by tremendous effort, and then only for a few seconds. The weight of a finger would send it downward. It seems as though this might be equally characteristic of his first or third type, or of the class of cases to

which I have called attention, and that the mechanism involved here is that either from injury or from their proximity to the base of the tender bursa the short rotators refused to do their work, therefore not holding the fulcrum firmly in place and permitting it to slip on the glenoid, in which case, a very large deltoid would be of as little value as one of microscopic size. A lever to be of any value must

FIG. 7.—Fracture of the great tuberosity of the humerus, involving the insertions of the supraspinatus, infraspinatus, and teres minor. The patient could start the arm in abduction only a few degrees, however, and with pain; motion forward and backward was preserved but restricted; external rotation was lost (involvement of the infraspinatus and teres minor); internal rotation was preserved (subscapularis intact). All motions were finally recovered. (X-ray by A. W. George, M.D.)

have a fixed fulcrum, and it must be, for the time being, at least, a firm and solid one. Disturb it in the slightest degree or render it unstable, even for the infinitesimal part of a second, and unless one instantly substitutes another point for the one disturbed, the greater the force at the long arm of the lever the quicker and more surely will that lever fail.